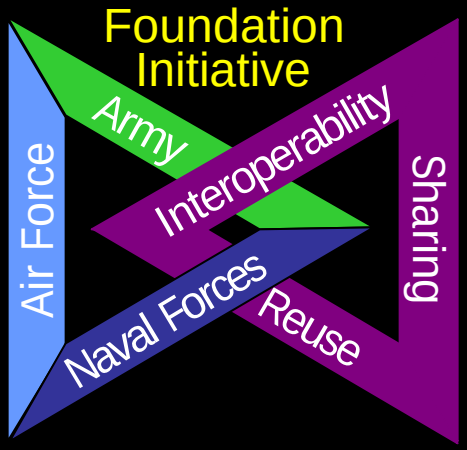
Interoperability Efforts

in Modeling & Simulation

and

in Test & Evaluation

High Level Architecture



Phil Zimmerman
HLA Program Manager

George Rumford
FI 2010 Technical Project Manager

Purpose

Domain / Scope

Technical Description

Developments

Implementations

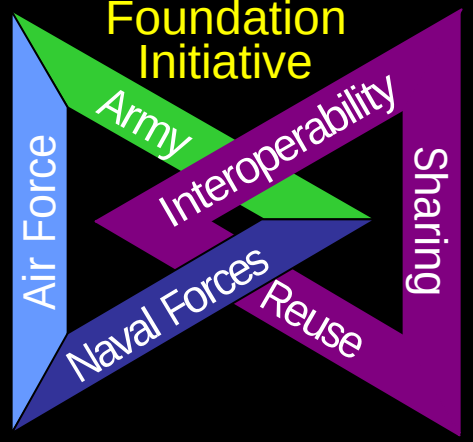
Supporting Tools

Standardization Efforts

Policy & Mandates

Summary

High Level Architecture



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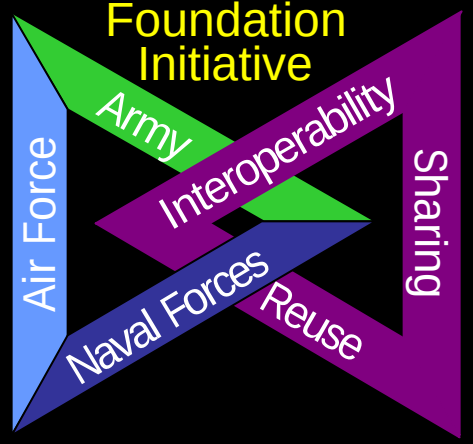


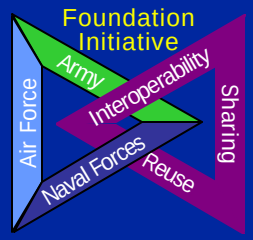
High Level Architecture

Role of HLA

- **Interoperability** requires the ability to both exchange data (Interface Specification) and to specify it consistently (Object Model Template)
- **Reuse** requires sharing of models, algorithms, parameter values, and executable simulation components (FEDEP)

Required degree of interoperability and reuse beyond that provided by HLA is a policy matter for each community of common interest

Foundation Initiative 2010 Mission Summary



Provide the Core Products necessary to:

- **Enable Interoperability among Ranges, Facilities, and Simulations in a quick, cost-efficient manner**
- **Foster Reuse for Range asset utilization and for future developments**

- **Supports the Warfighter (Joint Vision 2010)**
- **Enables Simulation Based Acquisition & STEP**
- **Fosters Test and Training Integration**
- **In the long term: SAVES MONEY!**

Lay the Foundation for Future Range Instrumentation

Purpose

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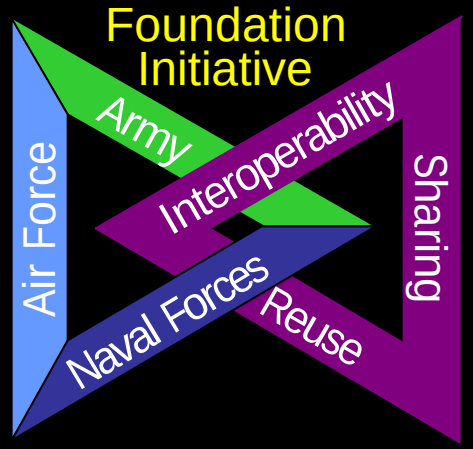


Standardization Efforts

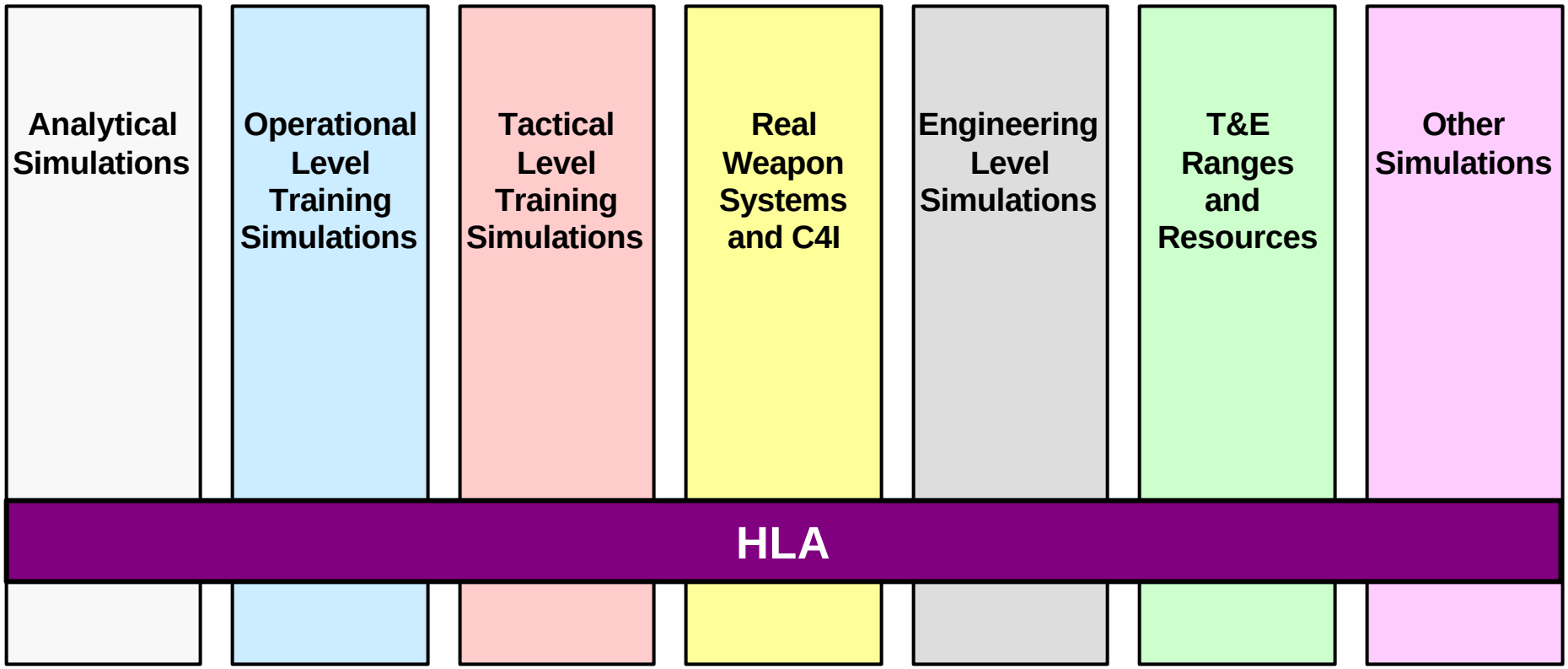
Policy & Mandates

Summary

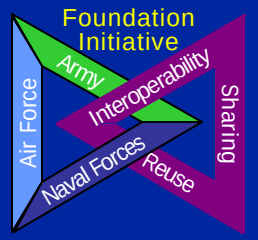
High Level Architecture

Scope of HLA

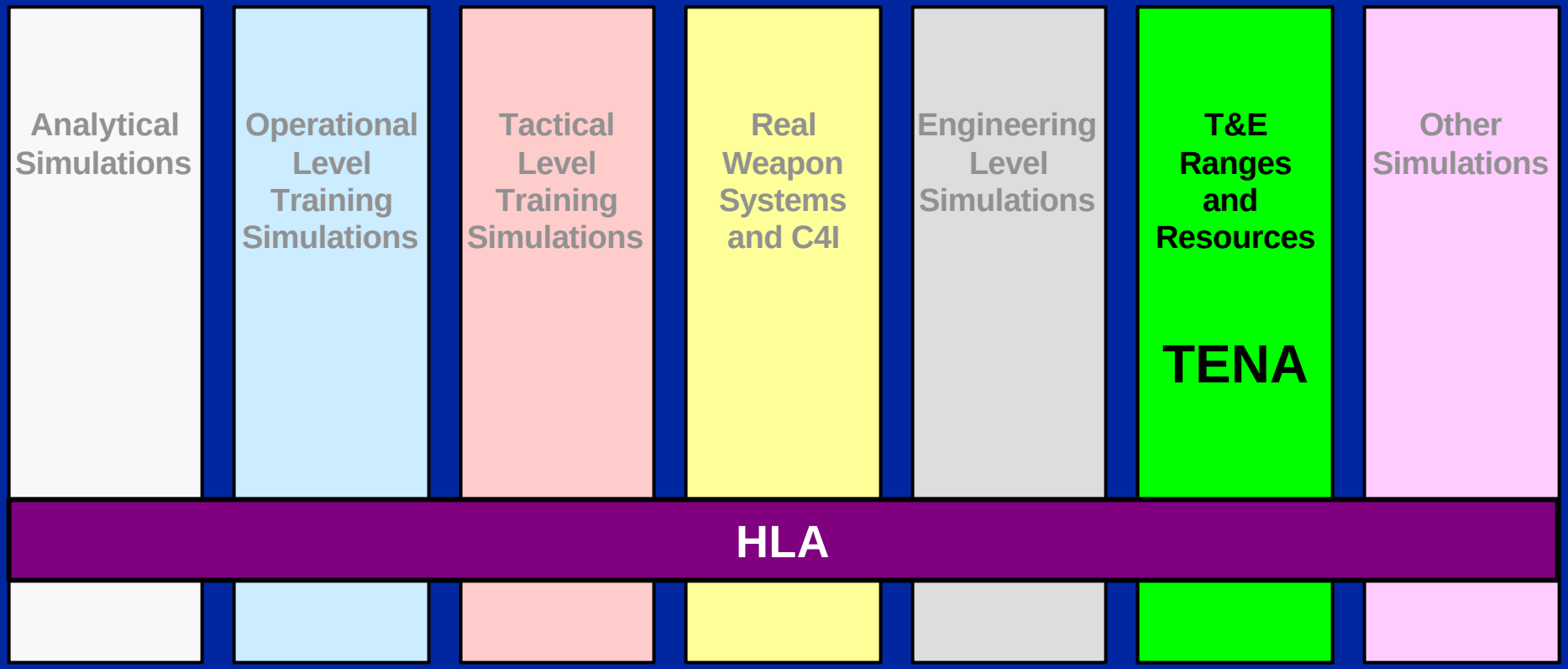
- **Domain neutral**
- **Applicable to ALL DoD Simulations**
- **Able to interface to real world systems – instrumentation, C4I, etc.**



Scope of TENA



- **Domain Specific**
- **Applicable to T&E Resources – Ranges, ISTFs, HWILs, SILs, M&S**
- **Not to preclude Training Resources – Ranges, Reconfigurable Simulators**



Purpose

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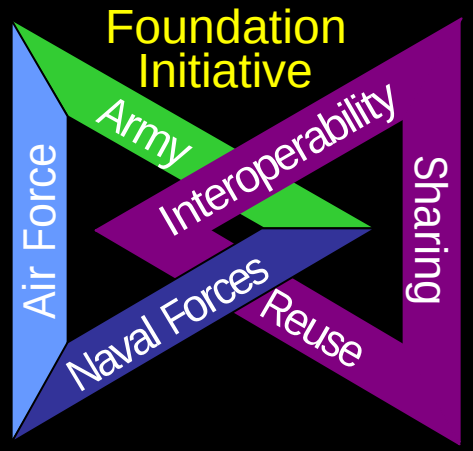


Standardization Efforts

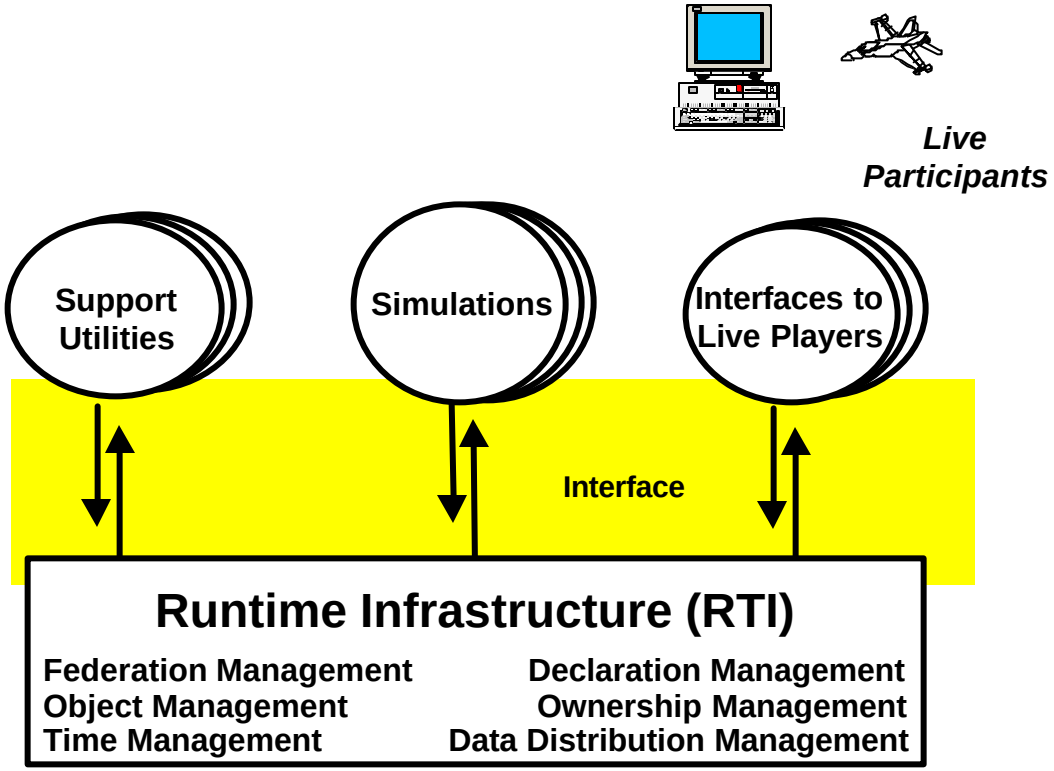
Policy & Mandates

Summary

High Level Architecture

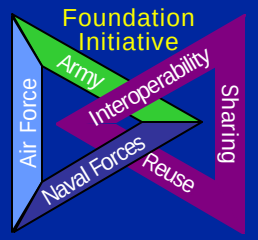
High Level Architecture

- **Architecture calls for a federation of simulations**
- **Architecture specifies**
  - **Ten Rules which define relationships among federation components**
  - **An Object Model Template which specifies the form in which simulation elements are described**
  - **An Interface Specification which describes the way simulations interact during operation**

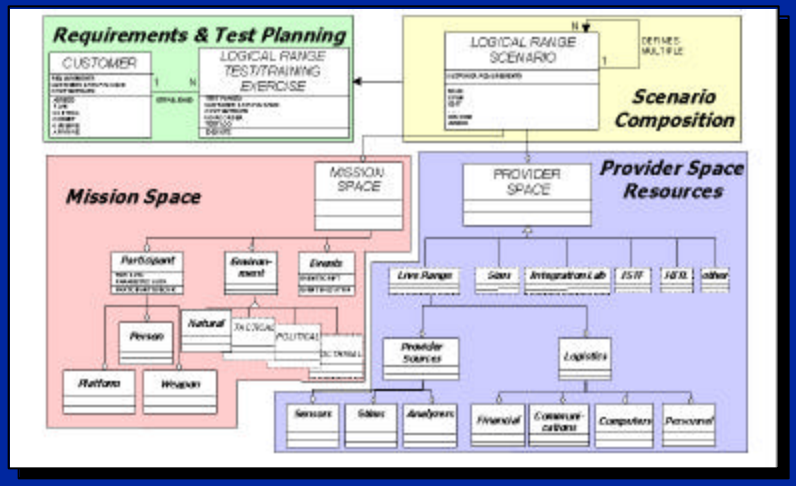


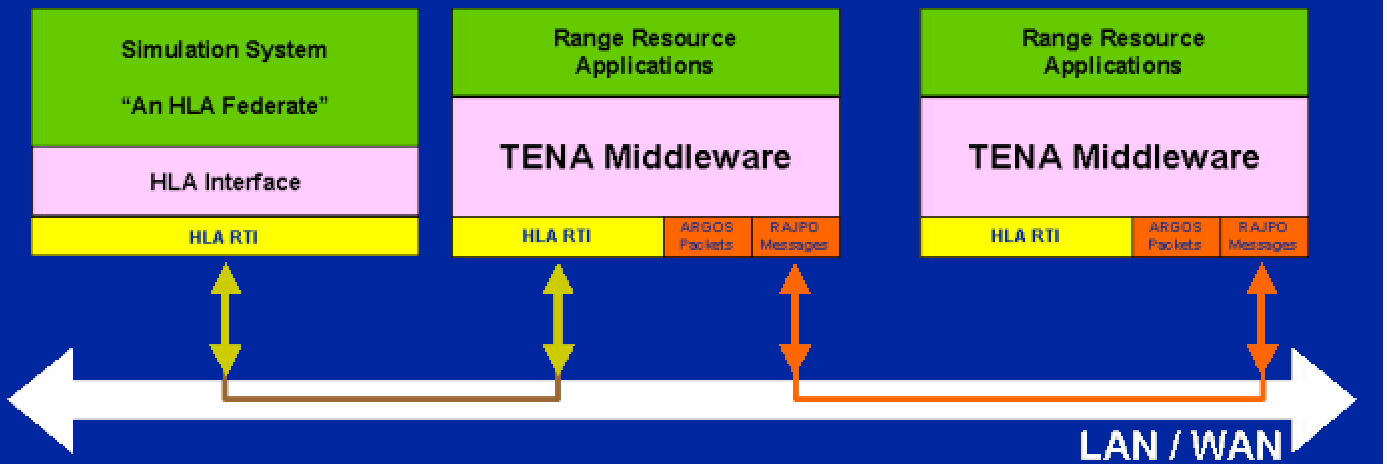
The HLA (architecture) is not the RTI (implementation); the HLA says there will be an RTI that meets HLA IFSpec

Test & Training Enabling Architecture (TENA)



- **Object Model**
  - Data Elements of Test / Exercise
    - System-under-Test / Training Participant
    - Range and Facility Resources
  - Includes Resource Functionality
- **Services**
  - Specification for the way Test Resources interact & exchange data
- **Rules**
  - Requirements to be compliant
  - Standards & Protocols





High Level Architecture

HLA Rules

FEDERATION

1 **Federations** shall have an **HLA Federation Object Model (FOM),** documented in accordance with the HLA Object Model Template (OMT).

2 In a **federation**, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI).

3 During a **federation** execution, all exchange of FOM data among federates shall occur via the RTI.

4 During a **federation** execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification.

5 During a **federation** execution, an attribute of an instance of an object shall be owned by only one federate at any given time.

FEDERATE

6 **Federates** shall have an HLA **Simulation Object Model (SOM),** documented in accordance with the HLA Object Model Template (OMT).

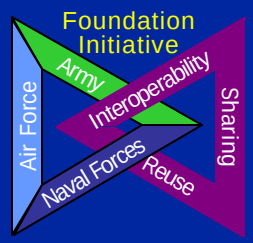
7 **Federates** shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM.

8 **Federates** shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM.

9 **Federates** shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM.

10 **Federates** shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation.

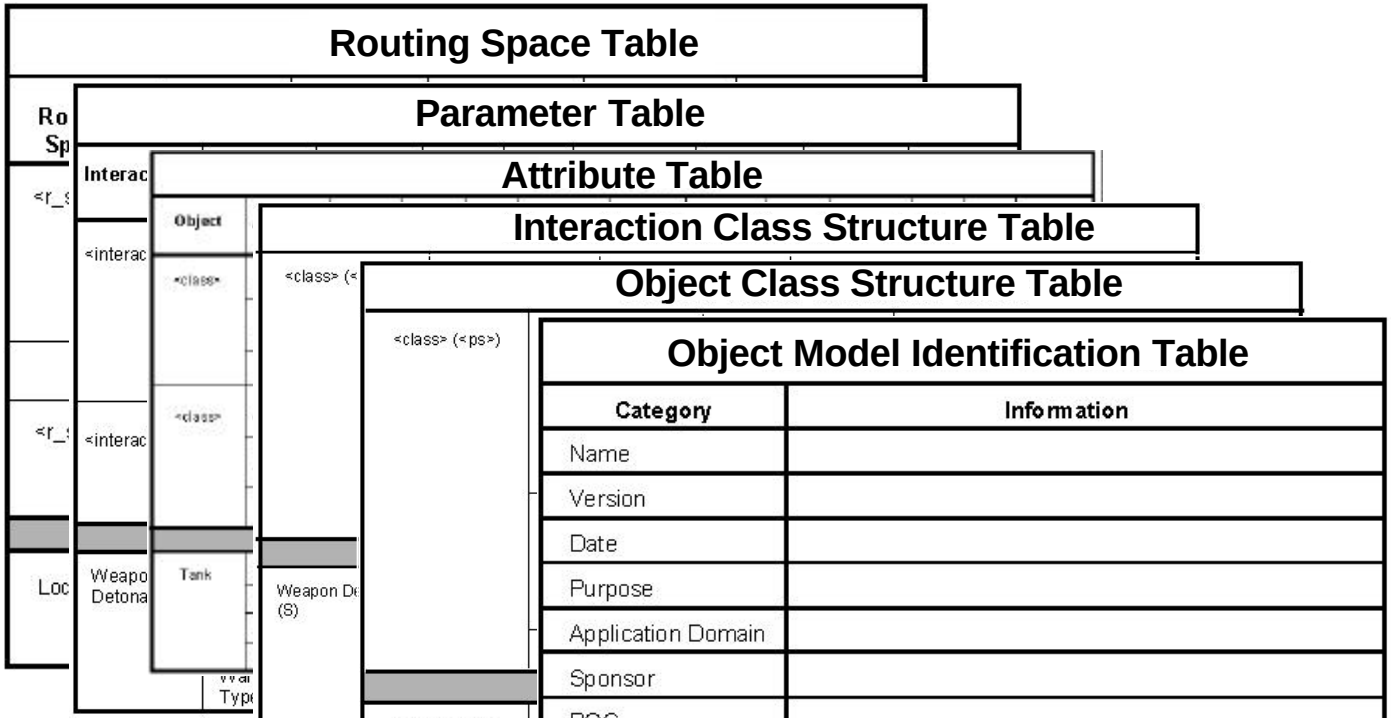
TENA Rules



- TENA Rules are in development
  - Candidate Resource rules
    - All resource objects shall be defined in the TENA Object Model
    - All resource objects shall use the TENA Base Object to track and maintain version and configuration control
  - Candidate Test / Exercise Conduct rules
    - Test / Exercise planning and development shall be performed in accordance with the TENA Exercise Process
    - All operations between TENA objects shall use TENA Services
- Considering Rules to give guidance on industry and community standards

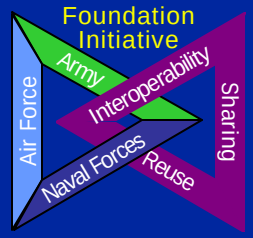
High Level Architecture

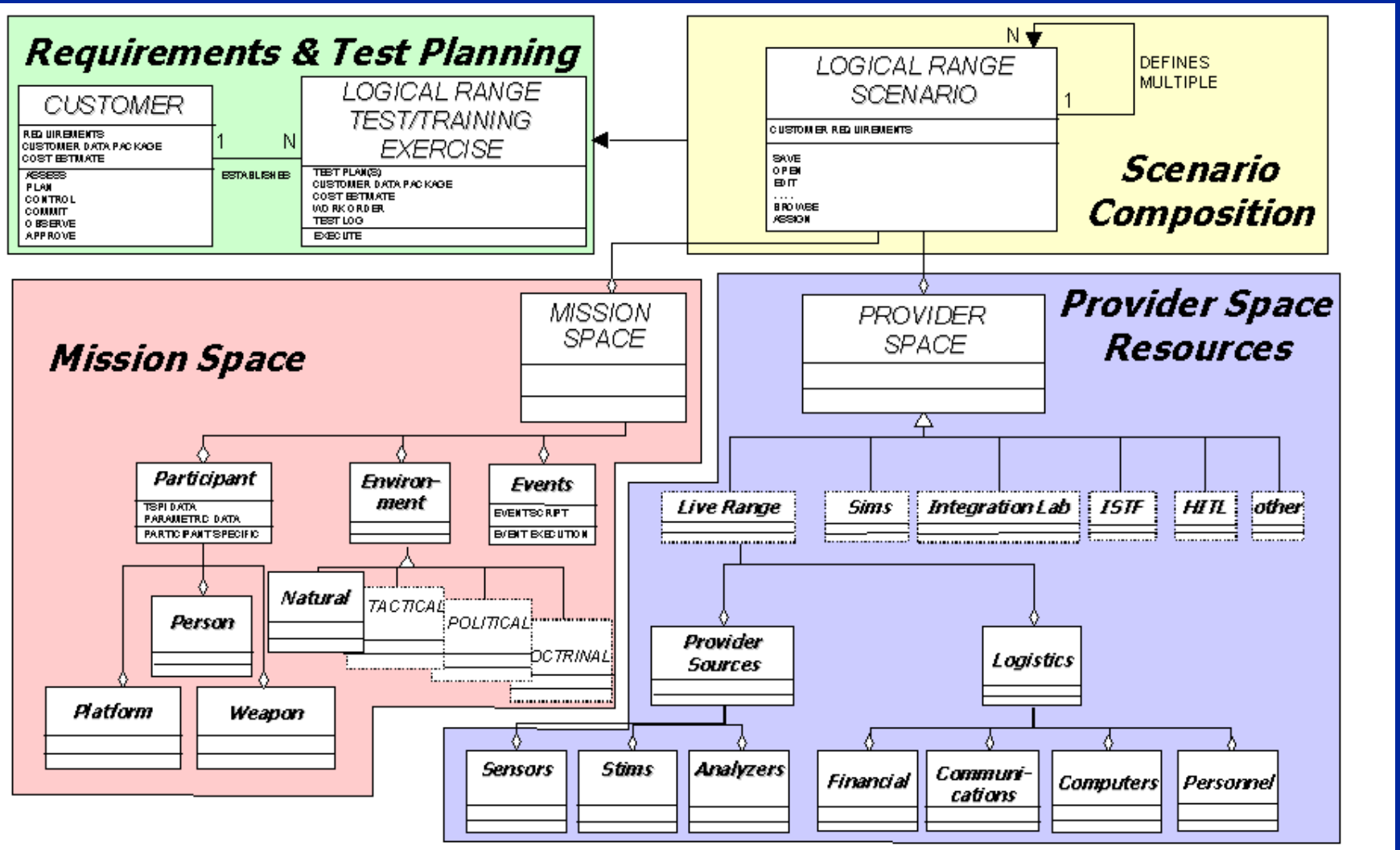
Object Model Template (v1.3)



Category	Information
Name	
Version	
Date	
Purpose	
Application Domain	
Sponsor	
POC	
POC Organization	
POC Telephone	
POC Email	
Name	Strike Simulation SOM
Version	1.0 Alpha
Date	1 Jan 1998
Purpose	To provide an example of an object model for a federate that simulates strike operations.

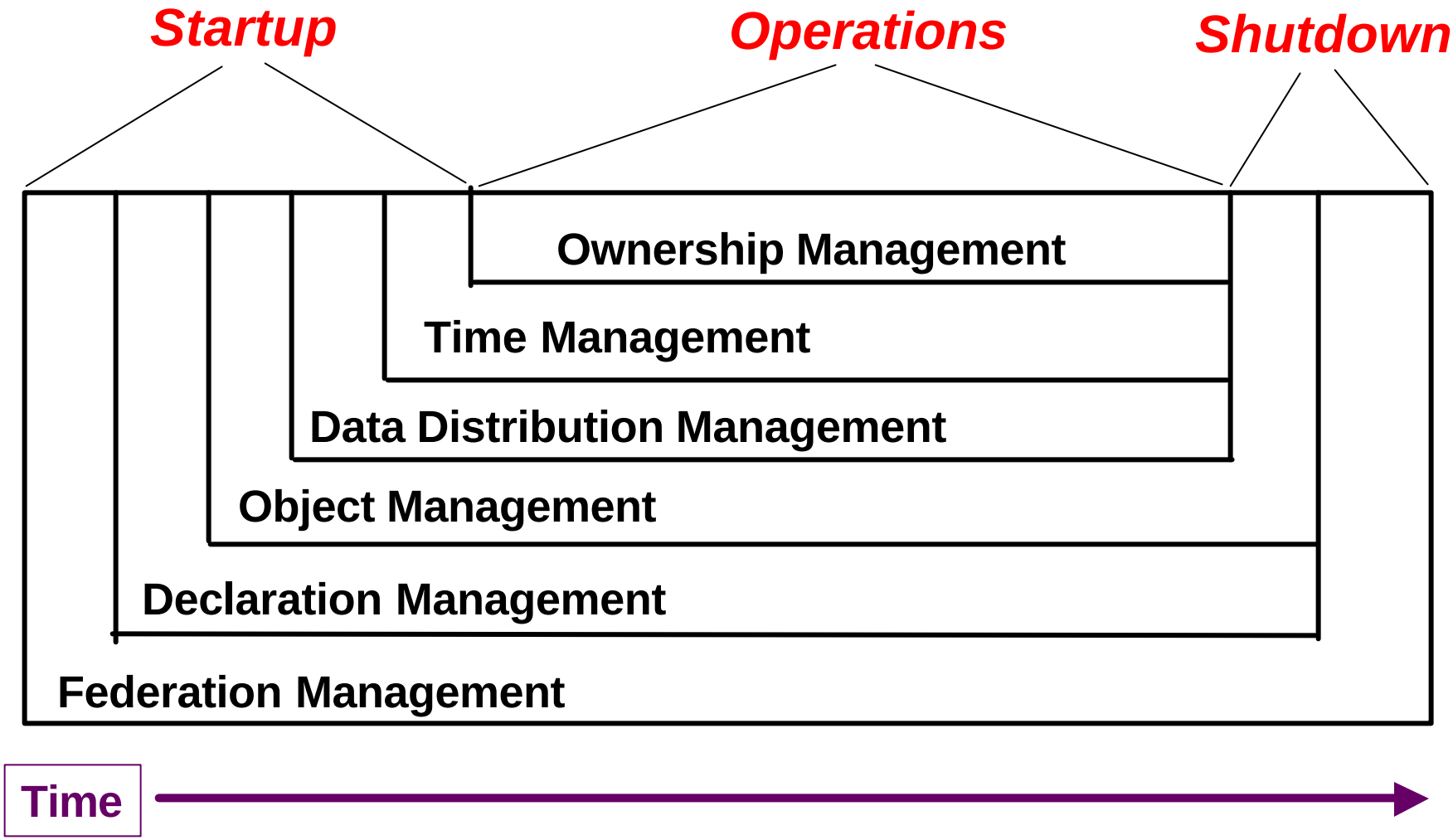
TENA Object Model



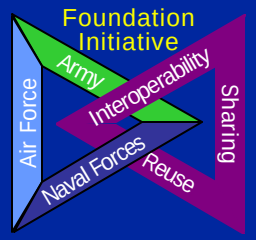


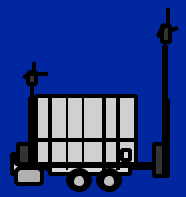
High Level Architecture

Interface Specification Services



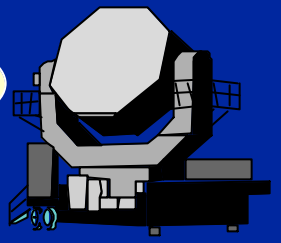
TENA Services
TENA Middleware

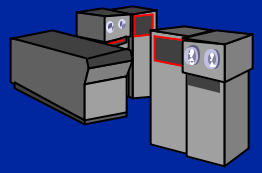




"Mission Space" Objects

"Provider Space" Objects





Test Resource Application Software

TENA Object Services

TENA Distribution Services

HLA Interface	IP Interface	TADL Interface	○○○	CORBA Interface
HLA RTI	Range Protocols	Tactical DataLink	●●●	CORBA

TENA Middleware

Standard API
to manipulate Test Data

Purpose

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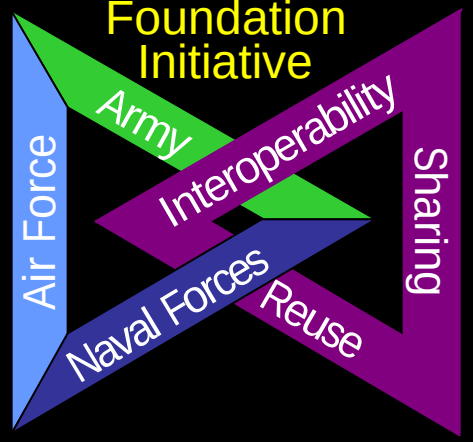


High Level Architecture

HLA Development

Industry Solicitation

Previous DoD architecture efforts

Mar 95

Initial definition of HLA

DoD Policy Issued 10 Sept 1996

Aug 96

Prototypes

Baseline definition of HLA

Checkpoints

Spec v1.1 2/97

Spec v1.2 8/97

Spec v1.3 2/98

Evolution

DoD Policy Reaffirmed 7 April 1998

IEEE Standardization Process begun 6/97

IEEE P1516 Drafts Approved for Balloting 3/99

IEEE approval 9/00

DoD Components working policy and implementation guides

We're Here! (1516?)

DoD-wide Architecture Management Group (AMG)

16 members

22 members

28+ members

Phase 1 Initial Definition

Phase 2 Baseline Development

Phase 3 Technical Transition

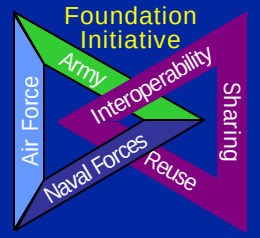
Phase 4 Product Transition

High Level Architecture

HLA Transition Strategy

- Using SEI's Transition Planning Process
- Continuation, but with decreasing resources
  - Federate Compliance Testing, and RTI verification
  - Tool distribution and Help Desk Support
  - RTI 1.3 and Reference Implementation of tools for 1516 (including RTI with limited ports)
- Discontinuation of free HLA Education
  - At least 2 commercial vendors offer HLA Education/Training
  - But continuation of authoritative information
- AMG will serve as HLA Advisory Body to DMSO
  - Composed of User programs, Service M&S Offices, supported by Technical Support Team
  - Meetings now held quarterly, at DMSO (41 held so far)

TENA Services Development Strategy



Foundation Initiative 2010

CTTRAs (1 thru 6)

OM Structure | Object Definitions | Standardization

TENA Project

TENA Baseline Report Oct 97

Domain Analysis

IKE

IKE 2

IKE 3

IOC

FOC

RCC Maintains Standards

Joint & Other CTEIP efforts

Service I&M projects

Development Test Cells

JADS SIT II

SETI

SimHARM

JTCTS

LOCAAS/JS

We're Here!

Range systems interfaces

HLA Experiments

Support Weapon Systems Tests

Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Initial Definition	Risk Mitigation	Technical Development	Implementation	Propagation & Maintenance

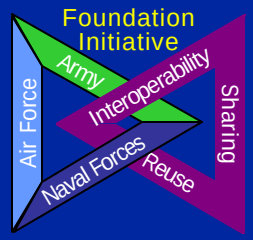
Architecture Management Team (TENA AMT)

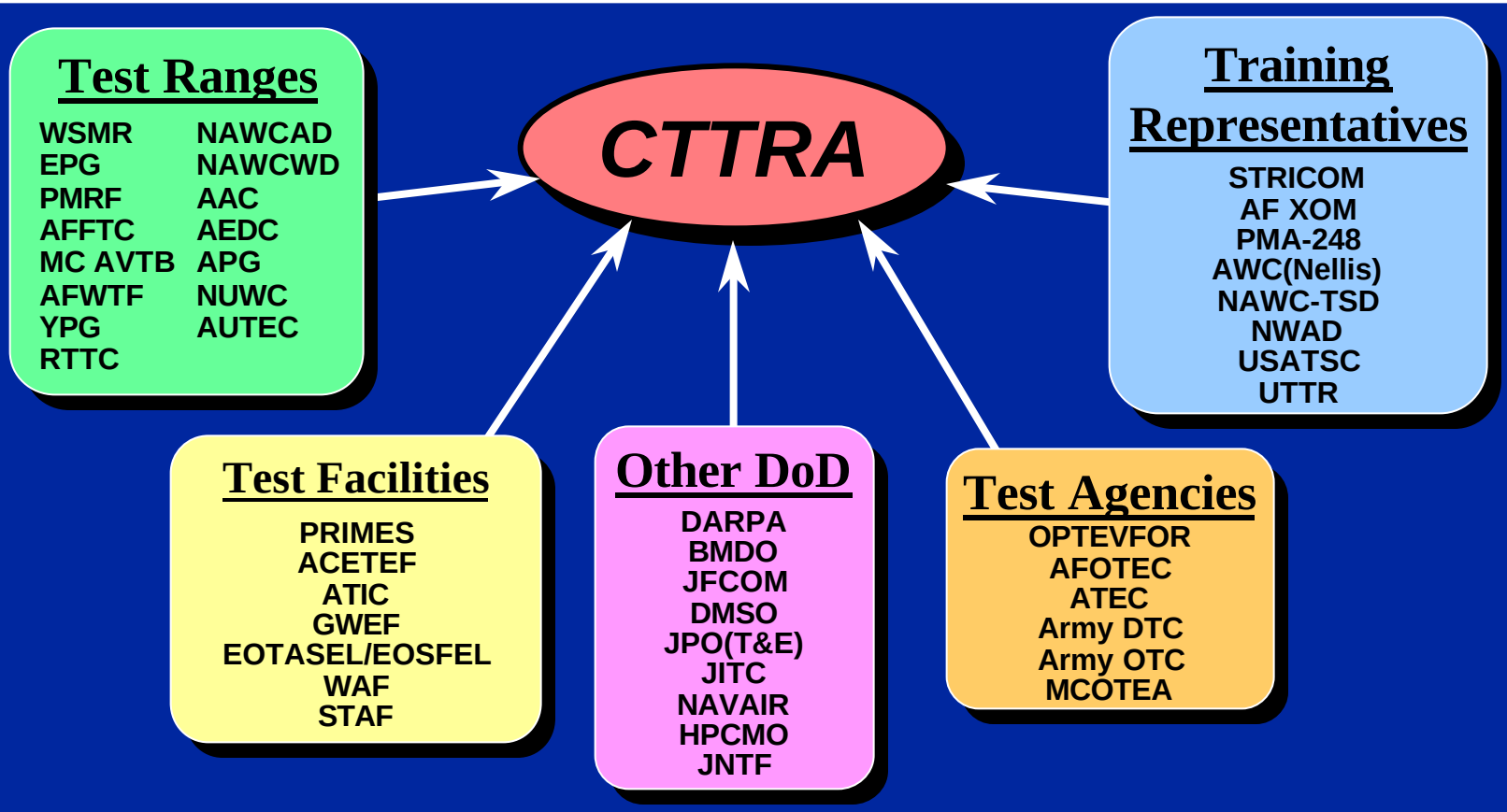
- **System Engineers & Technical Leads for the current major stakeholders of TENA**
  - AAC, Eglin AFB FL
  - NUWC, Newport RI
  - NAWC-AD, Pax River MD
  - WSMR, White Sands NM
  - RTTC, Huntsville AL
  - EPG, Fort Huachuca AZ
  - NAWC-WD, China Lake & Point Mugu CA
  - Virtual Proving Ground (VPG)
  - Common Training Instrumentation Architecture (CTIA)
  - PMRF Synthetic Range

Meetings every 4-6 weeks

- **Design Decisions / Trade-offs / Status**
- **TENA Use Cases / Prototype Test Strategies**
- **Technical Exchanges of Lessons Learned**
- **Issues & Concerns Identification, Investigation, & Resolution**

Common Test & Training Range Architecture (CTTRA)





- Systems engineers & software developers in the DoD Range and Facility community (both T&E and Training)
- 11 three-day workshops held
- Next workshop scheduled 31 Jul – 2 Aug 2001 in Colorado Springs

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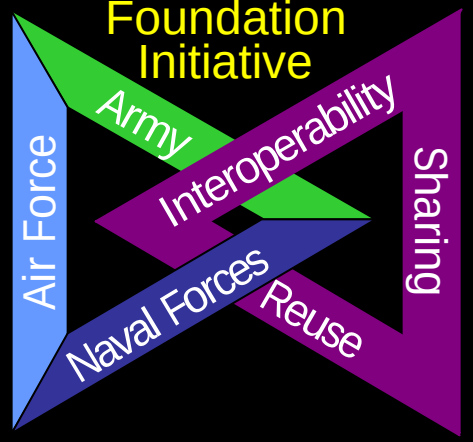
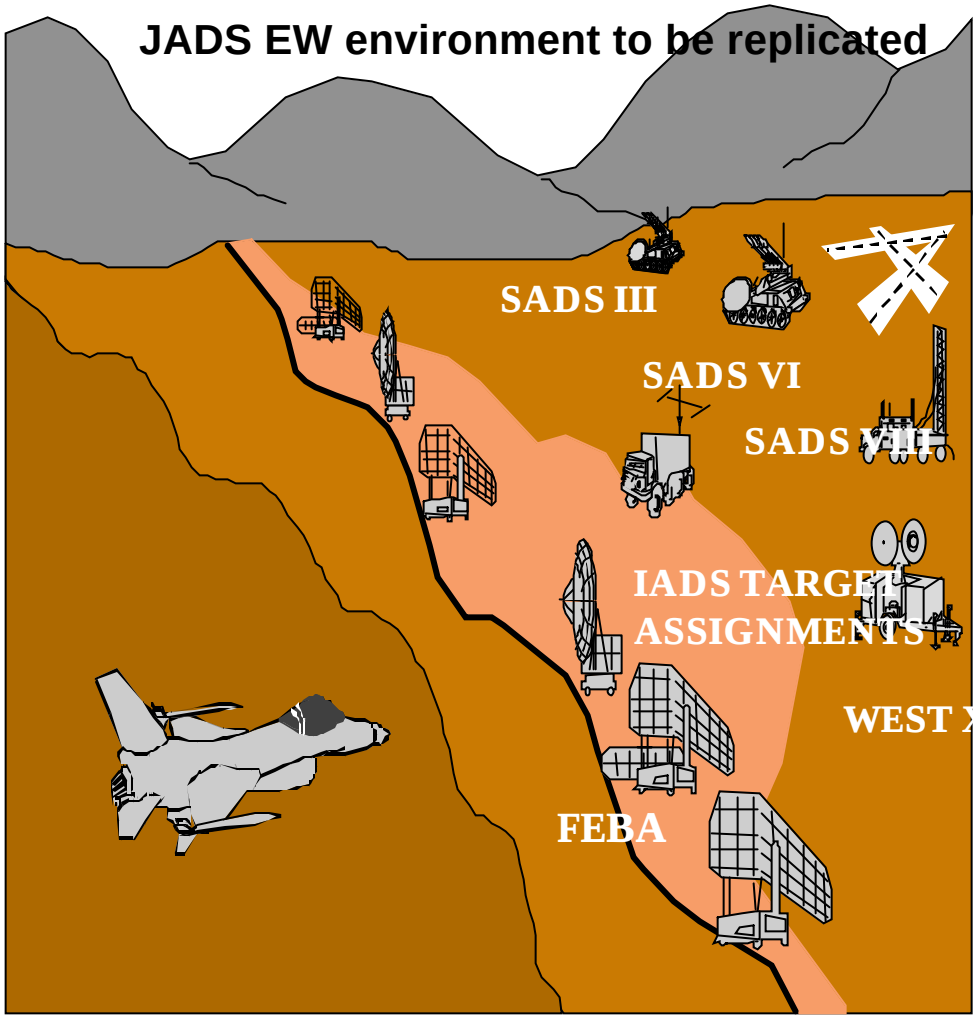


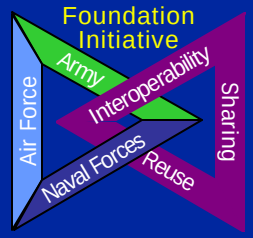
High Level Architecture

T&E Applications
JADS-EW / EDISON / JSF



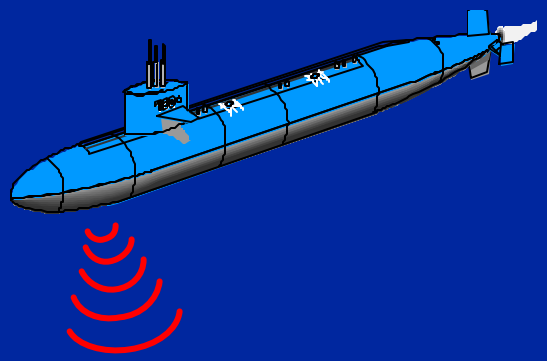
- **Link test hardware and live systems with simulation**
- **Early testing of 'conceptual systems' or 'virtual prototypes'**
  - DoD 'JADS' program links F-16 in anechoic chamber in Maryland with enemy air defense systems in Ft. Worth and test control in Albuquerque
  - European Union project 'EDISON' linking space station hardware facilities
  - JSF VSWE 7 – two interconnected federations

Hardware-in-the-Loop to Open Air Range Testing

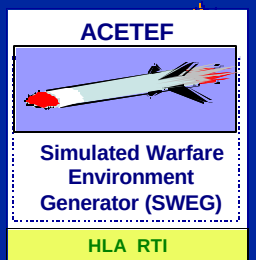


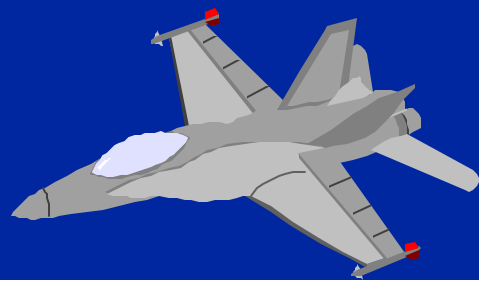
- **JADS System Integration Test (SIT) II**
  - Leveraged JADS SIT test at Eglin (DIS)
  - Involved 3 “entities”:
    - Shooter: Blue Aircraft (Eglin Range)
    - Threat: Red Aircraft (Eglin Range)
    - Weapon: AMRAAM (GWEF)

- **Synthetic Environment for Tactical Integration (SETI)**
  - Leveraged Navy SETI test at AUTEC (DIS)
  - Involved 3 “entities”:
    - Shooter: Blue Submarine (AUTEC)
    - Threat: Red Submarine (AUTEC)
    - Weapon: Blue Torpedo (WAF)

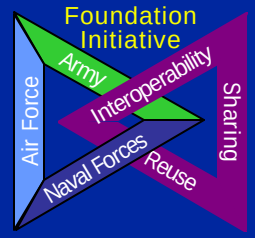


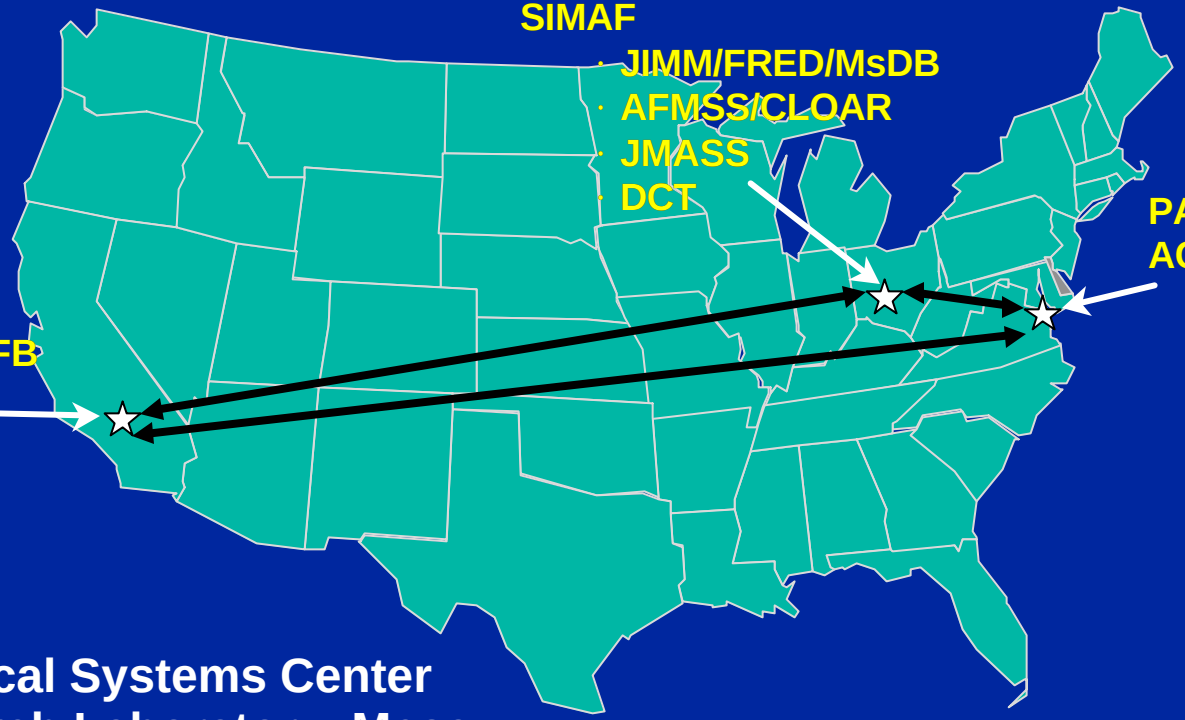
- **Simulated HARM (SimHARM)**
  - Leveraged HLA Engineering ProtoFederation
  - Involved 3 “entities”:
    - Shooter: Blue Aircraft (CTR)
    - Threat: SAM Site (ACETEF)
    - Weapon: HARM (ACETEF)





Joint Strike Fighter (JSF)
VSWE 7





WRIGHT-PATTERSON AFB
SIMAF
- JIMM/FRED/MsDB
- AFMSS/CLOAR
- JMASS
- DCT

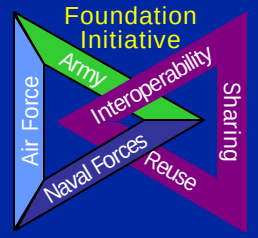
PATUXENT RIVER NAS
ACETEF - MFS
- JIMM/FRED/MsDB
- AFMSS/CLOAR
- EADSIM
- TADL
- MDST
- DCT

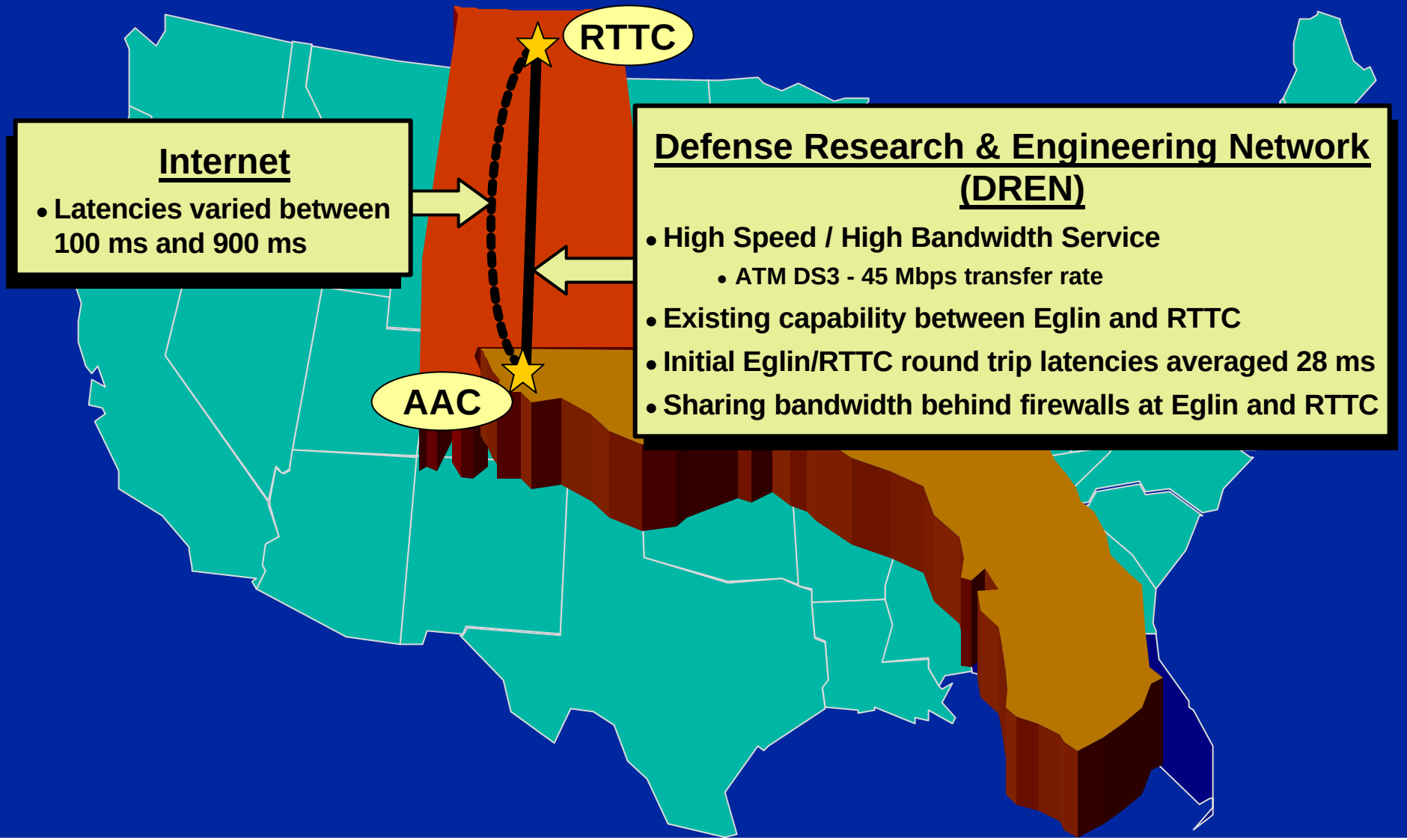
EDWARDS AFB
AFFTC
- DIADS
- DCT

- Aeronautical Systems Center
- AF Research Laboratory, Mesa
- Naval Air Warfare Center - AD
- Electronic Systems Center
- Space & Missile Center
- AFOTEC

- Joint Accreditation Support Activity
- Defense Modeling & Simulation Office
- Joint National Test Facility
- Boeing
- Lockheed Martin Tactical Aircraft Systems

TENA Prototype Testing





Internet

- Latencies varied between 100 ms and 900 ms

Defense Research & Engineering Network (DREN)

- High Speed / High Bandwidth Service
  - ATM DS3 - 45 Mbps transfer rate
- Existing capability between Eglin and RTTC
- Initial Eglin/RTTC round trip latencies averaged 28 ms
- Sharing bandwidth behind firewalls at Eglin and RTTC

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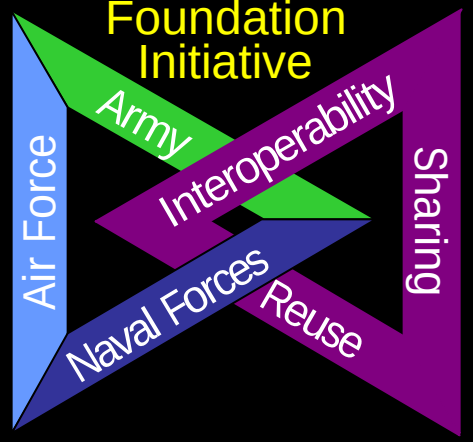
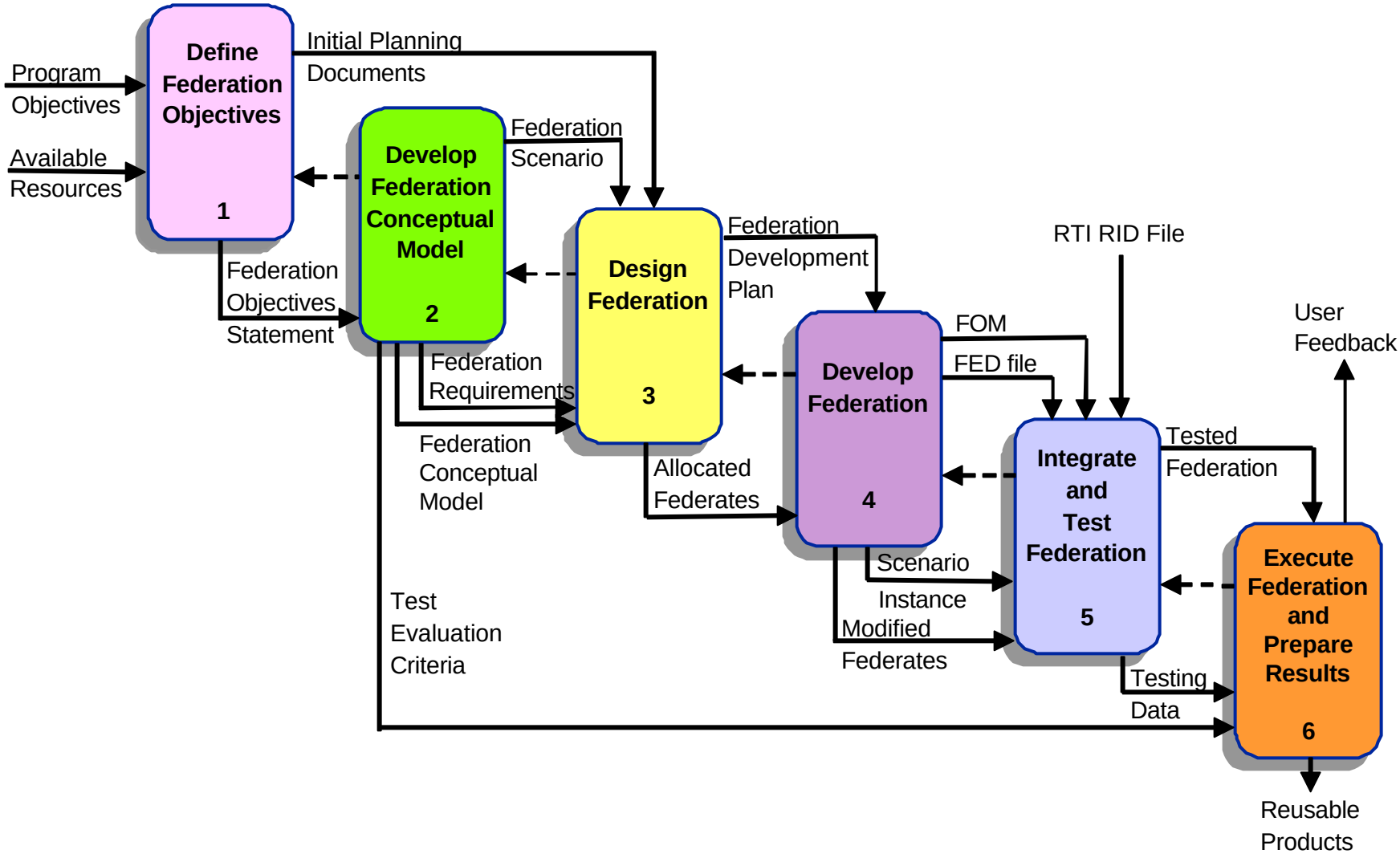


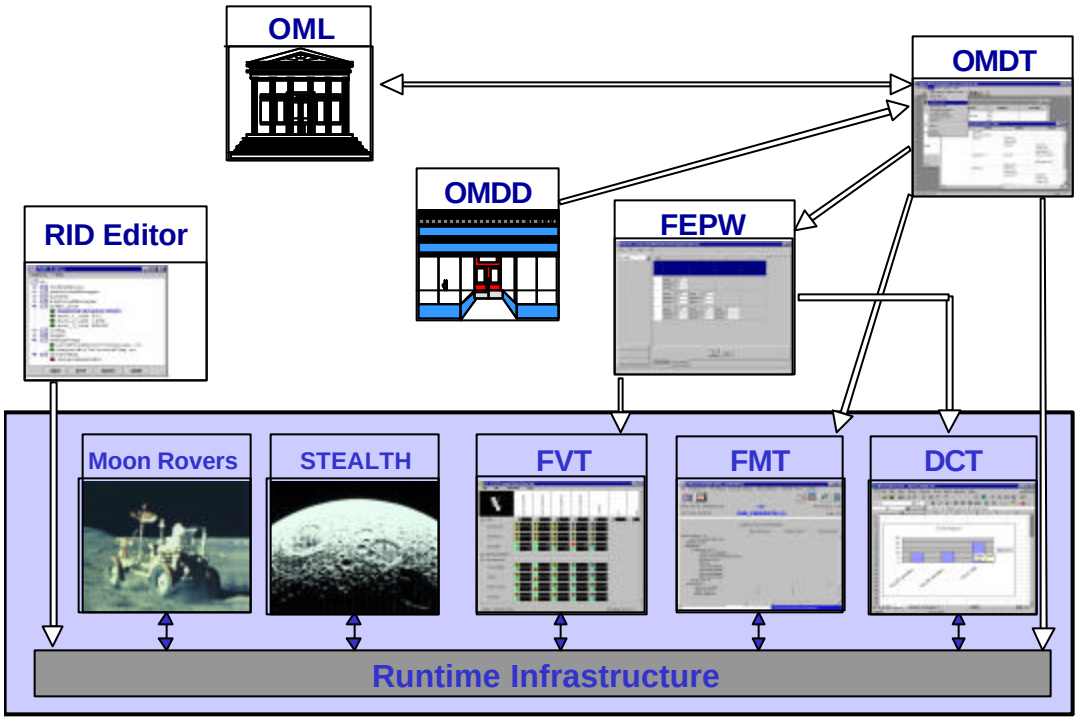
High Level Architecture

Applying HLA
Federation Development & Execution Process



High Level Architecture

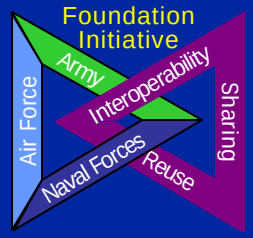
HLA Supporting Tools

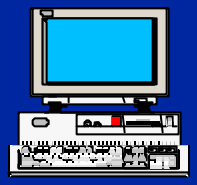


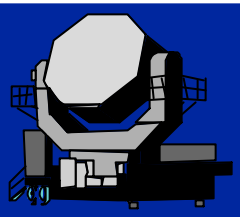
- Current free software
  - RTI 1.3NG - verified
  - Obj Model Development Tool
  - Fed Exec Planners Workbook
  - RID Editor
  - Federation Verification Tool
  - Federation Mgt Tool
  - Data Collection Tool
- 1516 Upgrades in progress
- Open tools bulletin board
  - for commercially available tools

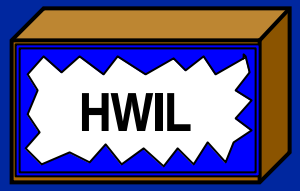
The idea behind tool development was to develop a proof of principle that they could be developed, and to determine whether or not the tool's concept was useful. It is anticipated that the commercial market will take over…

TENA Architectural Construct with FI 2010 Tools









Non-TENA System

Non-TENA System

Non-TENA Communications

Range Resource

Range Resource

Range Resource

TENA Gateway

TENA Interface Repository

TENA Middleware

Test / Exercise Data Archive

Test / Exercise Planner

Test / Exercise Manager

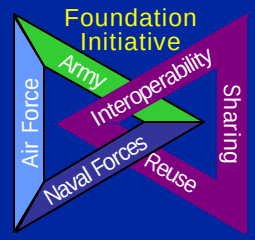
Data Collector

Resource Manager

Test / Exercise Analyzer

FI 2010 Tools

FI 2010 Tools



- **Resource Manager**
  - Define & browse TENA Object Model (Range Resource interfaces)
  - Define communication services
  - TENA Object Model compliancy checking
- **Test / Exercise Planner**
  - Test / Exercise scenario design
  - Test Simulation and Performance Prediction
  - Instrumentation Configuration and Optimization
  - Pre-test check-out / risk mitigation
- **Test / Exercise Manager**
  - Test / Exercise scenario control
  - Resource status, monitoring, and control
  - Test / Exercise visualization
  - Data monitoring and management
- **Test / Exercise Analyzer**
  - Data extraction and reduction
  - Comparative and statistical analysis

Purpose

Domain / Scope

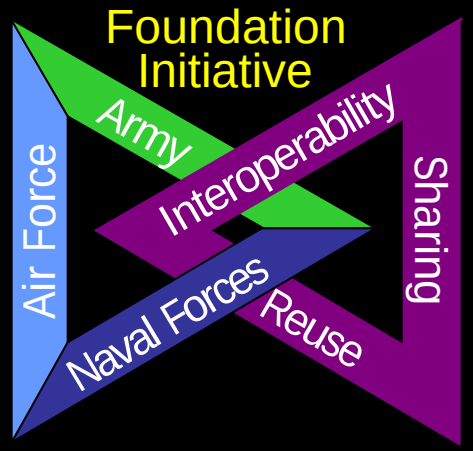
Technical Description

High Level Architecture

Developments

Implementations

Supporting Tools



Standardization Efforts

Policy & Mandates

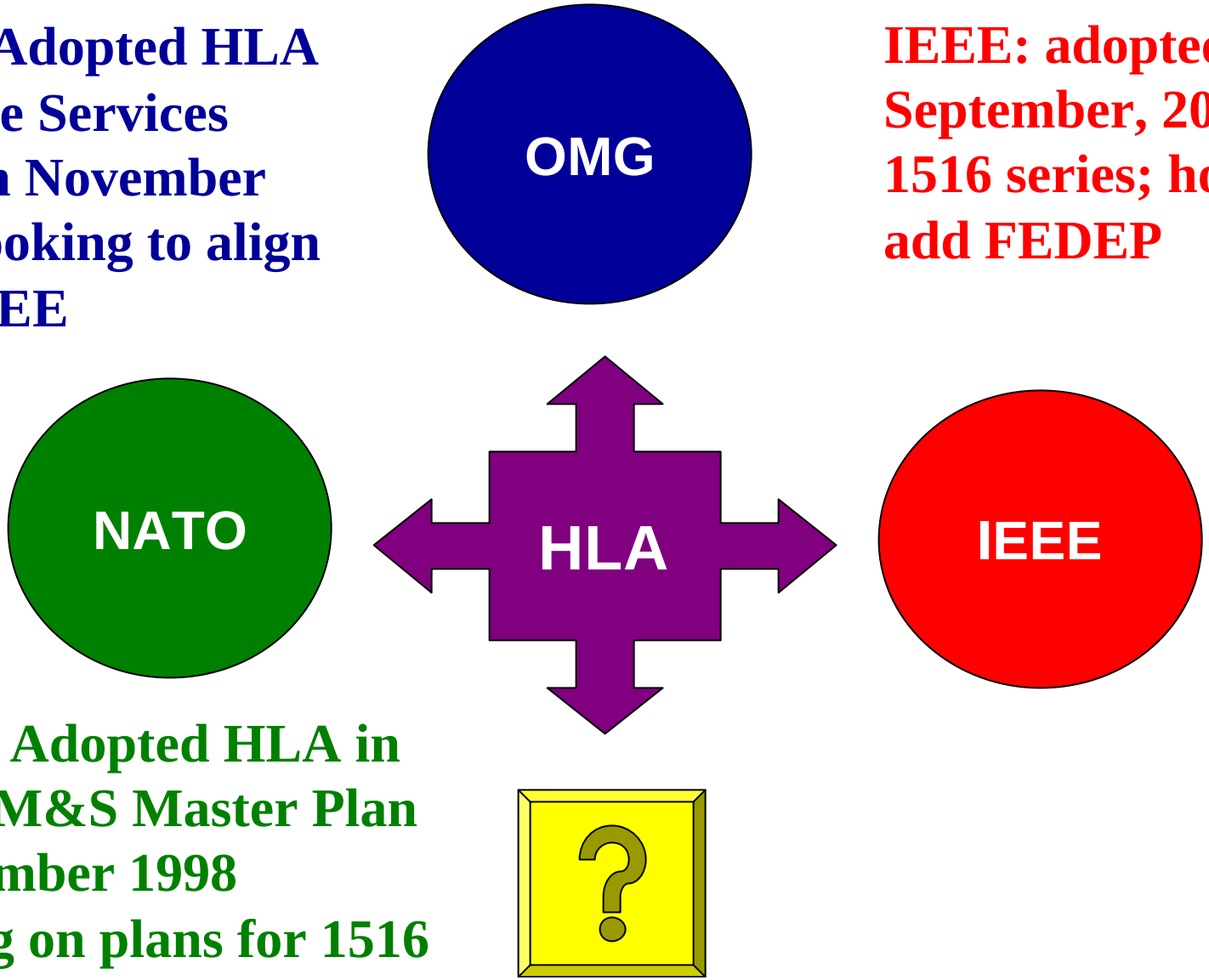
Summary

High Level Architecture

HLA Standardization Efforts

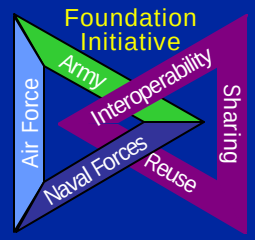
OMG: Adopted HLA Runtime Services (v1.3) in November 1998; looking to align with IEEE

IEEE: adopted in September, 2000 as 1516 series; hoping to add FEDEP



NATO: Adopted HLA in NATO M&S Master Plan in December 1998 working on plans for 1516

TENA Standardization Efforts



Goal is for the Range Commander's Council to standardize TENA

- **Working with RCC subgroups to review and adopt major components of the TENA Object Model**
  - **Data Reduction and Computer Group (DR&CG)**
  - **Modeling and Simulation Group (M&SG)**
  - **Electronic Tracking and Measurements Group (ETMG)**
  - **Optical Systems Group (OSG)**
  - **Timing and Telecommunications Group (TTG)**
- **RCC Blue Ribbon Panel recommendation to establish a new RCC subgroup for 'Architecture'**
  - **Consists of chairs from other subgroups**
  - **Oversee and maintain TENA Object Model**
  - **Oversee and maintain TENA Services Specifications (the TENA API)**

Purpose

Domain / Scope

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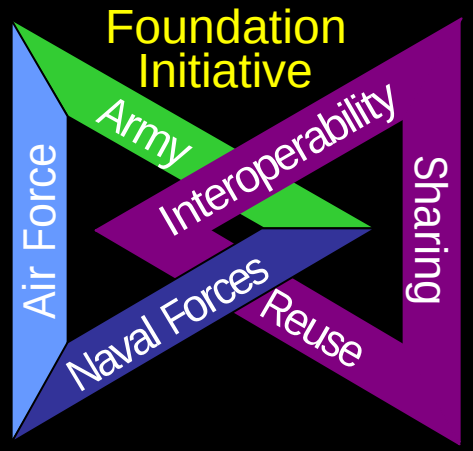
Supporting Tools



Standardization Efforts

Policy & Mandates

Summary

High Level Architecture

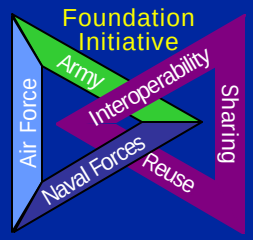
HLA Policy

"… This agreement attests to the fact that the HLA has gained the Department's simulation stakeholders' acceptance and strong support through tried and proven technical performance, capability, maturity and potential. Furthermore, the wide spread adoption of HLA is contributing not only to the military capability and readiness of US forces but also to a growing number of allied and friendly nations as well, laying a firm foundation for international interoperability…"

J. S. Gansler, USD (AT&L)
03 November 2000

- **Within the MOA:**
  - **"…Establishes the HLA as the technical architecture for interoperability and reuse among the signatories…"**
  - **"… any other alternative must be justified…"**
  - **"…DoD components shall establish their own policies and procedures for transitioning their simulations to HLA or excluding them based on requirements, resources, Component priorities, or security. All exclusions from HLA shall be documented, justified by the DoD Component…"**

TENA Policy



Joint Test and Training Range Roadmap

"All investments in the development and acquisition of major new test and training range instrumentation, to include major upgrades, will be integrated into an appropriate roadmap in accordance with the JTTRR process. The resulting roadmaps will be submitted to the Defense Test and Training Steering Group for approval."

- **'Major' means $1M in any year or $5M over life of program**
- **'Test & Training' means all investments in either the test or the training communities (or both) that exceed that threshold**
- **Section 4 calls for a common "Foundation Architecture, Standards, and Protocols" to be adopted within DoD ranges and facilities**
- **DTTSG identified HLA and TENA as the starting point solution to the common 'foundation' architecture for DoD Ranges**

Purpose

Domain / Scope

Technical Description

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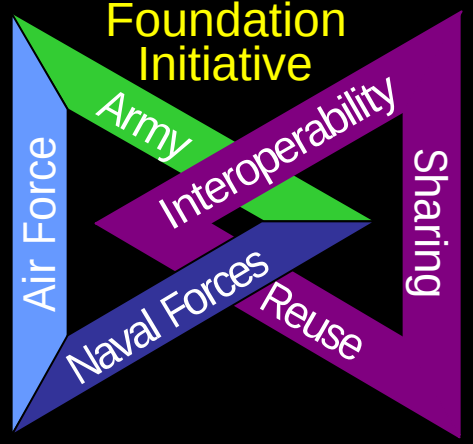
Policy & Mandates

Summary

High Level Architecture



High Level Architecture

Summary

- **High Level Architecture (HLA)**
  - Interoperability and Reuse for DoD Simulations
  - In Implementation throughout the DoD
  - Becoming an Industry and an International standard
- **Test and Training Enabling Architecture (TENA)**
  - Interoperability and Reuse for Test Resources
  - In Development & being tested at several Ranges
  - Becoming a Range Commander's Council standard

HLA & TENA are complementary in Purpose, Design, Development, and Implementation